Computation choices made by children:

What, why and how

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reports on the classroom implications of research designed to determine the computation choices made by 10–12 year old students. He discusses what choices were made, why they were made and how successful students were in executing their choices.

Mathematics curriculum documents highlight the need for students to be able to choose from a repertoire of computational tools and strategies (Curriculum Council, 1998; Education Department of Western Australia, 1998; National Council of Teachers of Mathematics, 2000), but little direction is given as to how children make the choice as to which form of computation to use in any given situation.

In setting the standard for computation in Australia the *National Statement on Mathematics* (Australian Education Council, 1991) included the following comments.

> All school leavers should feel confident in their capacity to deal with the computational situations which they meet daily, and number work should reflect the balance of number techniques in regular adult use… Students should develop the ability to judge the level of accuracy needed, learn to estimate and approximate, and use mental, calculator and paper-and-pencil strategies effectively and appropriately in different situations… This requires that they:
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> - decide what operations to perform (formulate the calculation);
> - select a means of carrying out the operation (choose a method of calculation);
> - perform the operation (carry out the calculation);
> - make sense of the answer (interpret the results of the calculation).
>
> (p. 108)

A result of the preceding statement was the recommendation that children develop the ability to '*choose* and *use* a repertoire of mental, paper and calculator computational strategies' [italics added] (Curriculum Council, 1998, p. 187). A great deal is implied by this rather short but all-encompassing statement. The implications are that children should become proficient in the use of all methods of computation and they develop the ability to choose an appropriate computation method. This represents a significant departure from current practice where children are either told which computation approach should be applied or where the class text indicates the form of computation to be used.

Little research (Price, 1995; Reys, Reys & Hope, 1993) was available on what computation choices were made by children. An earlier study by Reys, Reys & Hope (1993) found that written calculations dominated computation choice. However, they did not ask the students why particular choices were made. The researchers did note a variation in computation strategy choice according to the nature of the numbers used in each item.

Following-on from these findings, I interviewed 78 students from a variety of grades and schools to determine their choice of strategy use and the reasons behind such choices. The same 18 questions were used for all students as it allowed for some comparisons to be made across year groups for the various items. After solving each question, individual students were asked about their computational strategy choice. The students were then asked if they could solve the items using another method. In the following section, I focus on the initial method chosen by the students. For more detail on each of the items see Swan (2002).

The choices students made

Table 1 shows overall initial computation strategy choice data for all 18 questions.

Table 1. Percentage of initial computation strategy choice for all questions (n = 78).

Mental	Written	Calculator	Mixed	No Method
36	26	28	6	5

Findings indicated a preference for mental methods. Mental methods were favoured as a first computation choice in 36% of cases. Written methods accounted for 26% of all first computation choices and 28% chose calculator methods. In some cases it was impossible to separate the mix of methods used and this represented 6% of the total. The data also indicated that 5% were unable to choose a method to start the computation.

The general trend outlined in Table 1 suggests that students were exercising a computation choice. No one particular computation method dominated to the exclusion of other methods and the methods individual students used varied. No evidence was found to indicate that any individual student had used a single computation method for all 18 questions. Interestingly, there was also less reliance on written methods than expected.

As a general trend, students tended to make more use of calculators and showed less reliance on written methods than students in previous research. It appears that rather than make more use of mental methods, however, students opted for more calculator use.

There are some clear trends. Written methods were favoured for multiplication questions. Mental methods were favoured for in context (shopping items). Percentage and fraction questions caused the most difficulty in making choices. Questions involving zeros also caused problems for many students. Many students tried to 'take off' and 'add zeros', often with little success.

How students made computation choices

In most cases there was little or no hesitation when making the choice as to which method to use when solving a problem. There was little evidence to support the notion that students carefully examine a question before choosing a computation method. On a few occasions it was observed that students, having embarked on a particular method, found that it was inappropriate and abandoned it in favour of another.

Most students tended to use rudimentary criteria to make computation choices. These are listed below along with examples to illustrate each one. ('I' refers to the Interviewer and 'S' to the student response).

Big numbers and time taken to complete a calculation

Students often referred to 'big numbers' as a reason for making particular computation choices, particularly as a reason for not using a mental method. The time to complete a calculation seemed to weigh heavily on student's minds when making computation choices. Reasons such as: 'it's faster; it's quicker; it's quick and easy; it would take longer and it would take too long', were all used in support of either mental or calculator methods. At times more than one reason was given for making a computation choice as is shown by the following extract.

I: I noticed that you used a calculator, why was that?
S: Big sum.
I: Could you do it any other way?
S: On paper, but it would take forever.

In the following extract, time and the size of the numbers are mentioned as the reasons for choosing to use a calculator.

I: Why did you use a calculator?
S: I would definitely use a calculator because it takes too long on the paper, it's pretty big.

Speed was also mentioned as the reason for choosing to complete 28 + 37 using a mental method.

S: I could do it faster.

Speed of calculation, however, was not restricted simply to choosing to use a calculator or mental method as the following extract shows.

S: I probably could have done it in my head but it would have taken way longer and I prefer writing than using the calculator.

Recognised a weakness

Students appeared to be very aware of their weaknesses. They would use expressions such as 'I'm not good at', or 'I can't do'. Perceived weaknesses began to dominate the thinking of students to the point where computation choice became restricted. Specific weaknesses mentioned by students included:

S1: I don't really understand fractions.
S2: Because it's a decimal times.
S3: Because I can't do a point times something else.

It should be noted that students who were often critical of their own ability, at times, seemed overly harsh in their assessment of their ability. Knowledge of multiplication facts was often quoted as a reason for making a particular choice.

I: It looked as though you were trying to do that in your head to start off with and then you changed to the calculator, why?
S: I don't really know my seven times table.

Teacher influence

The influence of the teacher and emphasis placed on various forms of calculation may be seen in the following extracts. The first example involved a two-digit multiplication (33 × 88). The student also noted that an alternative method could be used to solve the same question.

I: Why did you choose to do that with your pencil and paper?
S: Because it's easy enough to do. We do heaps of this in class and you get the hang of it. I could have done it on the calculator.

Two items involving zeros proved most interesting. It appeared that many students had learned to 'take off' and 'add zeros' with little understanding of why this worked — or in many cases — did not work. Consider the following example; 70 × 600.

I: You did that one in your head, why was that?
S: Because my teacher told us to do like, 7 × 6 and then just write down the answer and put a 0 on it?

A process of elimination or a last resort

It was clear that many students' computation choice was restricted for one reason or another. In some cases a lack of understanding of how to enter fractions or decimals into a calculator or read the display of a calculator meant that students were unable to make use of the calculator as a computation alternative. Typical responses were 'because I don't know how to get fractions on the calculator'. In other cases the calculator became the default computation choice when other methods were unable to be employed. Consider the following comments made by two different students who chose to use the calculator.

S1: I don't know. I'm not that good at those ones; I haven't done it in class so I didn't think I would do it writing it down so I just did it with the calculator.
S2: In my head was a bit hard and then it was harder on paper, so I just had to use the calculator.

Knowledge of fraction-decimal equivalents would have assisted some students calculate using a mental method. A lack of place value knowledge and difficulties with zeros were also issues that served to restrict computation choice. For example, many students who tried mental methods to solve items involving zeros did not know what to do with all the zeros.

Metacomputation

There was some evidence of 'metacomputation' or thinking about the computation process. For example, when solving the question 33 × 88, one student who used pen-and-paper to calculate the answer to be 464 042 stated: 'that's way wrong. It's too big. Way too big.' One student who was observed entering a calculation into a calculator twice was asked why he had done so. The answer was most revealing.

S: Because I think I pressed something wrong in the first place.
I: What in your head told you that you had pressed something wrong?
S: Because the answer was too small, 29 x 31, it's got to be over 100.

Success rate for each computation choice

The success rate for the various computation choices overall is shown in Table 2. This indicated that students choosing mental methods were least likely to arrive at a correct answer. Slightly over half of students choosing written methods were able to correctly calculate the answer. The result for mental methods, tends to be lower than it might, because many students chose mental methods as a first resort and clearly some of the items were too difficult for a typical student in the age range 10–12 to calculate mentally. It is of concern, however, that the success rate for students choosing mental methods was so low. It should also be noted that the success rate for using a calculator was not as high as one might expect.

Success rates for second and third choices were lower still as one might expect. In some cases, however, student's second and sometimes third choices proved to be more successful than their first.

Table 2. Percentage of correct answers according to chosen method (n = 78).

Mental	44
Written	54
Calculator	79

Implications for teaching

The article has provided a snapshot of student's computation choices; why they made them and how successful they were in executing them. From these findings and those of similar investigations, we can make suggestions as to how teachers can best support the development of flexible and appropriate strategy use in young children. For instance, teachers could:

- encourage discussion about computation choice;
- assist students to reflect on their computation strategy choice after completing a calculation;
- redress the balance of time devoted to all forms of computation;
- place more emphasis on understanding numbers and number properties;
- increase the focus placed on estimation; and
- place less emphasis on speed of calculation.

Students should be free to exercise their computation choice, but they should be prepared to justify their choice if the teacher challenges them. In many cases mental computation should be encouraged as a first resort, although choices will vary according to competence with all methods of calculation. Once a calculation has been completed, students should also be encouraged to reflect on the choice(s) they have made. In this way it is hoped students will learn to make better computation choices.

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